Atmospheric Research over Indian sub-continent using GIOVANNI data

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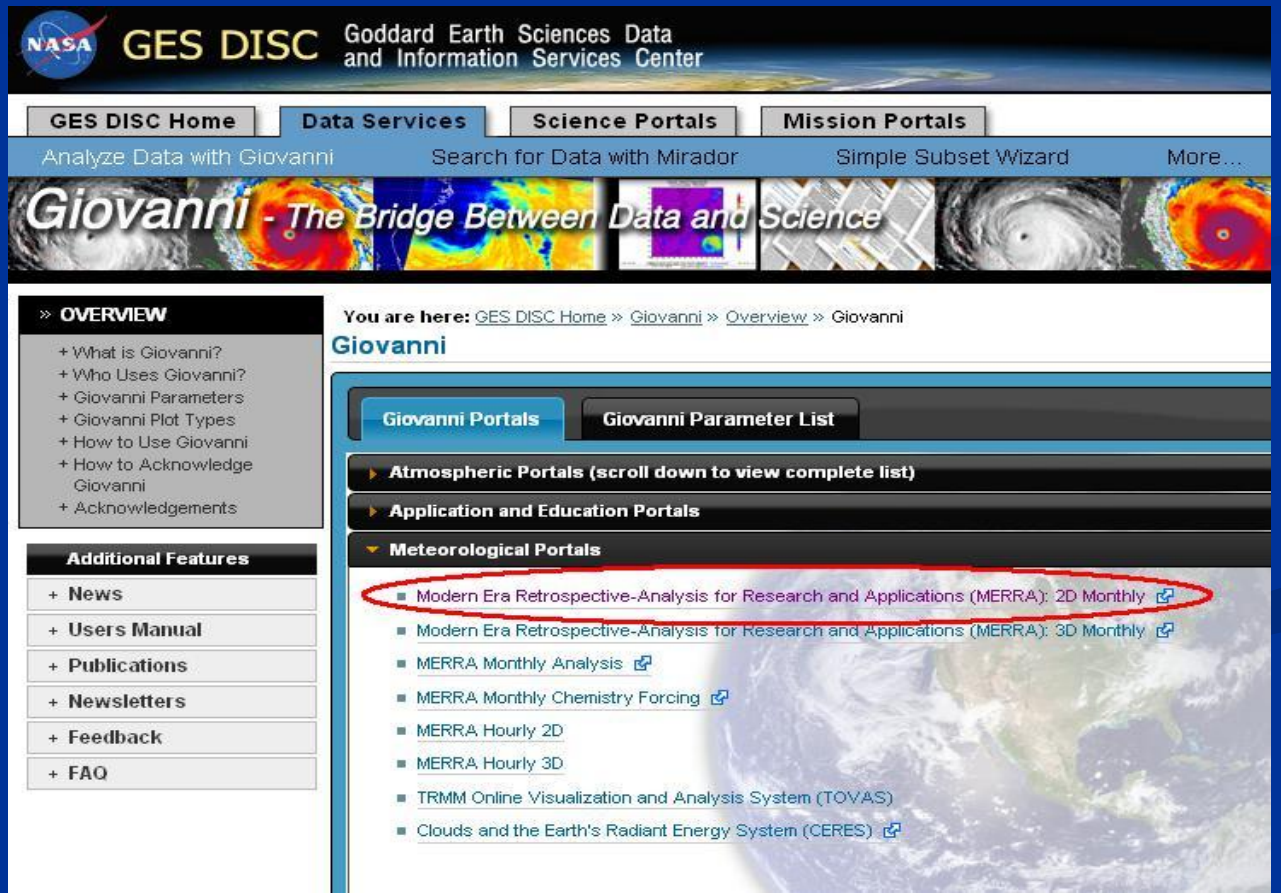
Solar dimming - brightening

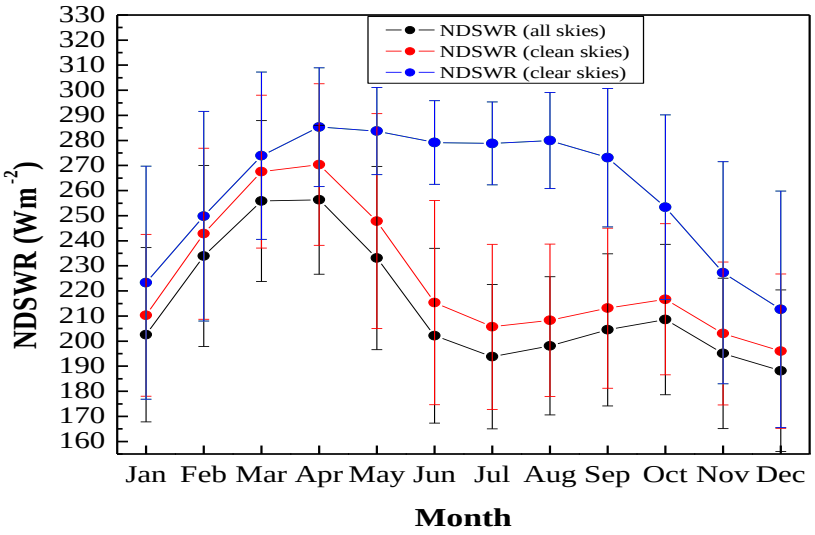
- Multi-decadal variations in solar radiation are significant for the future climate prediction. The solar radiation presents variations over the globe during the last 5 decades. A decrease (dimming) was found from mid 1950s to mid 1980s and a recover (brightening) afterwards (Wild, 2009). Over India this recover does not exist and the solar dimming is continuing (Padma Kumari et al., 2007; Ohmura, 2009). Present work examines the multi-decadal variations of solar radiation over south Asia.

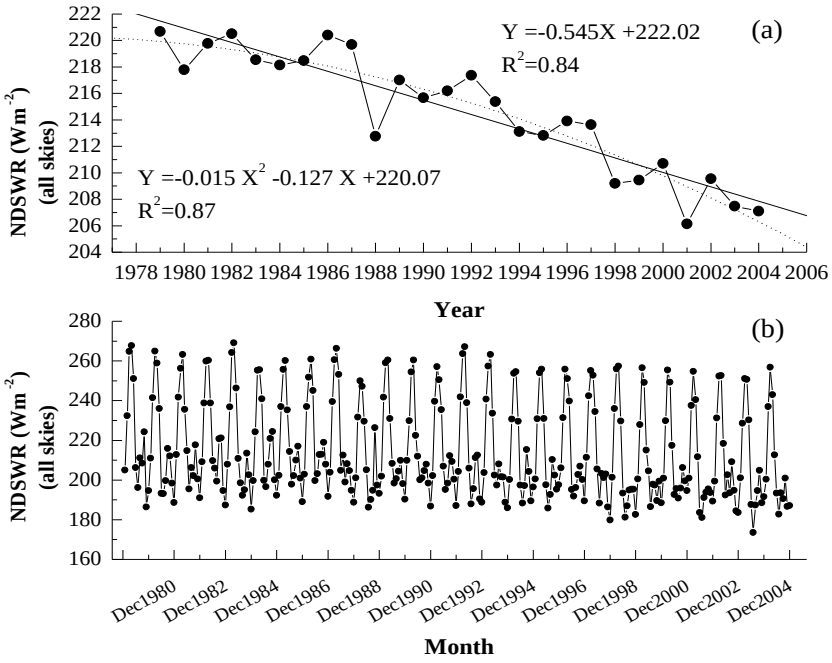


Solar radiation and cloud observations

- Study area: South Asia (0-30°N – 58-95°E).
- Data: Modern Era Retrospective-analysis for Research and Applications (MERRA 2D) available from Giovanni website.
- Examined parameters: Net Downward Shortwave Radiation (NDSWR): ground-reaching minus reflected and Cloud Optical Depth (COD) for all, low (<700 hPa), high (>400 hPa) and mid (700<h<400 hPa).
- Spatial resolution: 2/3 x 1/2 degrees
- Study period: 1979 - 2004

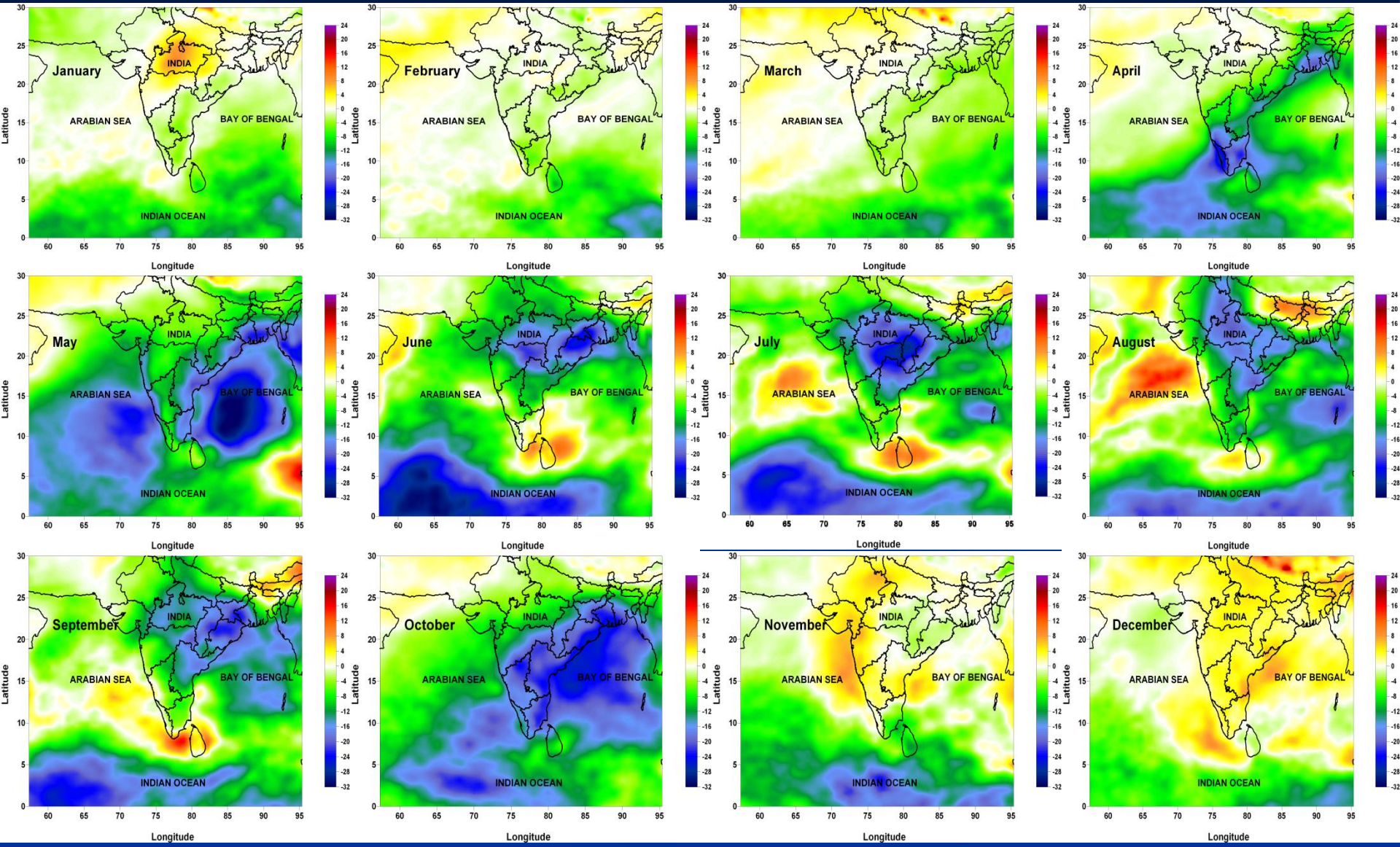
Variation in NDSWR



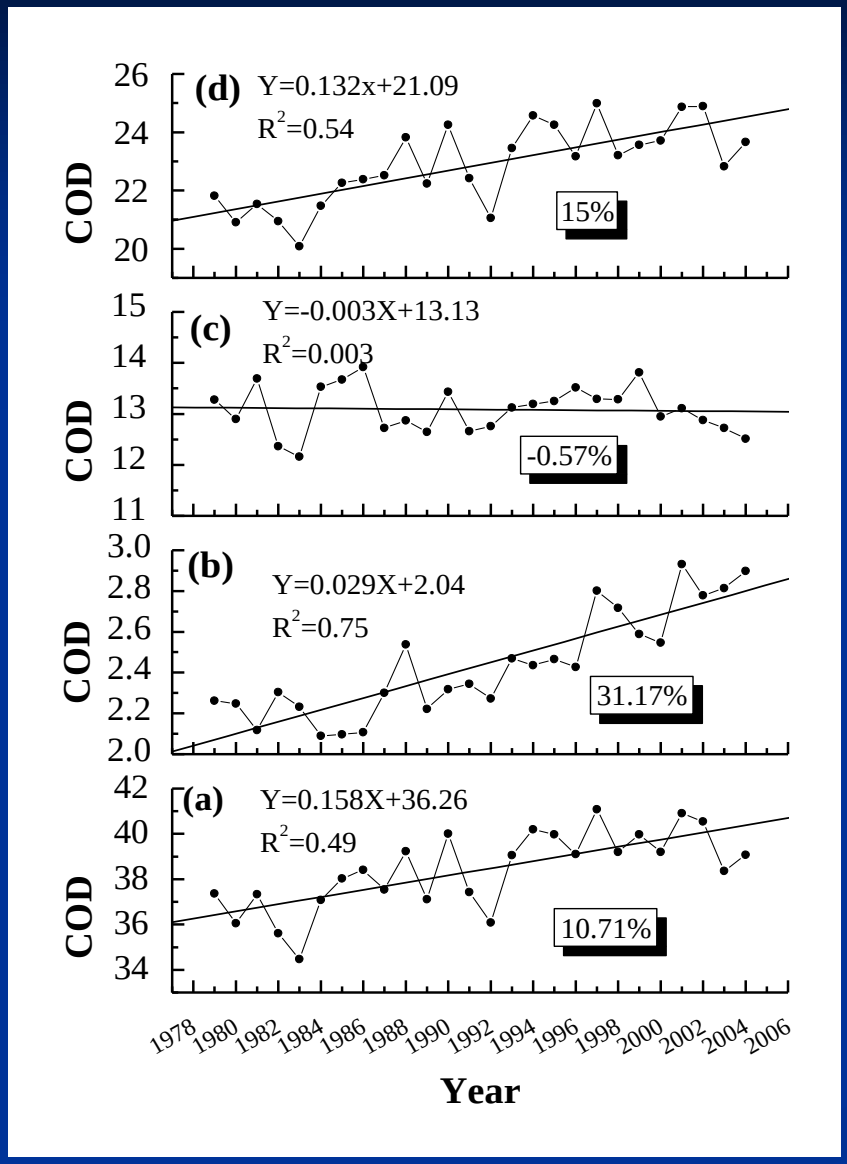


- Monthly-mean variation in NDSWR over south Asia for the period 1979-2004. In agreement with Padma Kumari et al. (2007) over 12 Indian cities. Large reduction in NDSWR in summer months due to clouds (monsoon).
- Significant reduction in NDSWR (all skies) over south Asia(–0.54 $Wm^{-2}\,yr^{-1}$). More intense in 1990s and 2000s opposite to other studies over the globe (North America, Europe).
- Similar negative trend for clean skies, slight negative trend (–0.052 $Wm^{-2}\,yr^{-1}$) for clear skies.
- About 1/10 of the solar dimming is attributed to aerosol trends. The clouds play the major role.

Spatial distribution of NDSWR trend (%)



Trend in COD



- Spatial distribution of NDSWR trend showed that cloud cover and cloud optical depth (COD) play the major role.
- COD increases over the area especially that of high clouds >400 hPa.
- Large decrease in NDSWR
- Increase in AOD also favors the NDSWR decline.

Main findings

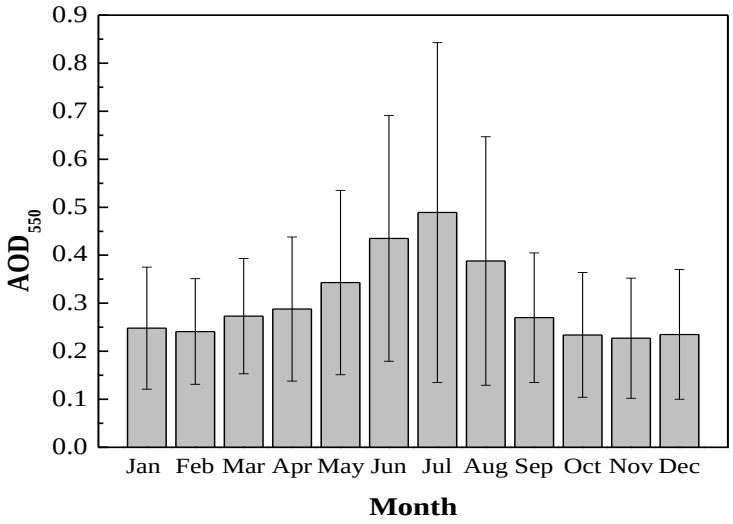
	NDSWR (all skies)		NDSWR (clean skies)		NDSWR (clear skies)	
	a	(%)	a	(%)	a	(%)
January	-0.267	-3.43	-0.271	-3.35	-0.094	-1.09
February	-0.176	-1.95	-0.174	-1.86	-0.061	-0.63
March	-0.265	-2.69	-0.267	-2.59	-0.049	-0.46
April	-0.683	-6.93	-0.701	-6.74	-0.088	-0.80
May	-1.089	-12.45	-1.143	-11.99	-0.079	-0.72
June	-0.744	-9.57	-0.781	-9.43	-0.041	-0.38
July	-0.649	-8.71	-0.681	-8.60	-0.021	-0.19
August	-0.577	-7.57	-0.596	-7.44	-0.026	-0.24
September	-0.649	-8.25	-0.670	-8.17	-0.049	-0.47
October	-1.006	-12.54	-1.032	-12.38	-0.081	-0.83
November	-0.287	-3.82	-0.289	-3.70	-0.04	-0.46
December	-0.052	-0.72	-0.053	-0.70	-0.009	-0.11

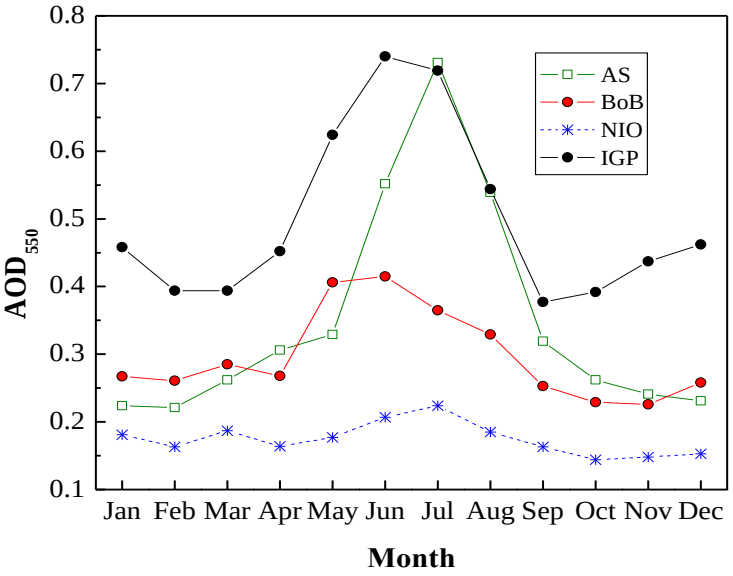
- Solar dimming is continuing over south Asia.
- Increasing trends of aerosols and clouds (high) are the responsible parameters.
- Clouds play the major role, especially in monsoon.

Aerosol measurements

- Study period 2000-2009.
- Terra-MODIS data over south Asia (0-30°N – 58-95°E).
- Level 3 Collection 005 from GIOVANNI (1°x1° spatial resolution).
- The whole region has been divided into 4 sub-regions, Arabian Sea (AS), Bay of Bengal (BoB), northern Indian ocean (NIO), Indo-Gangetic plains (IGP).

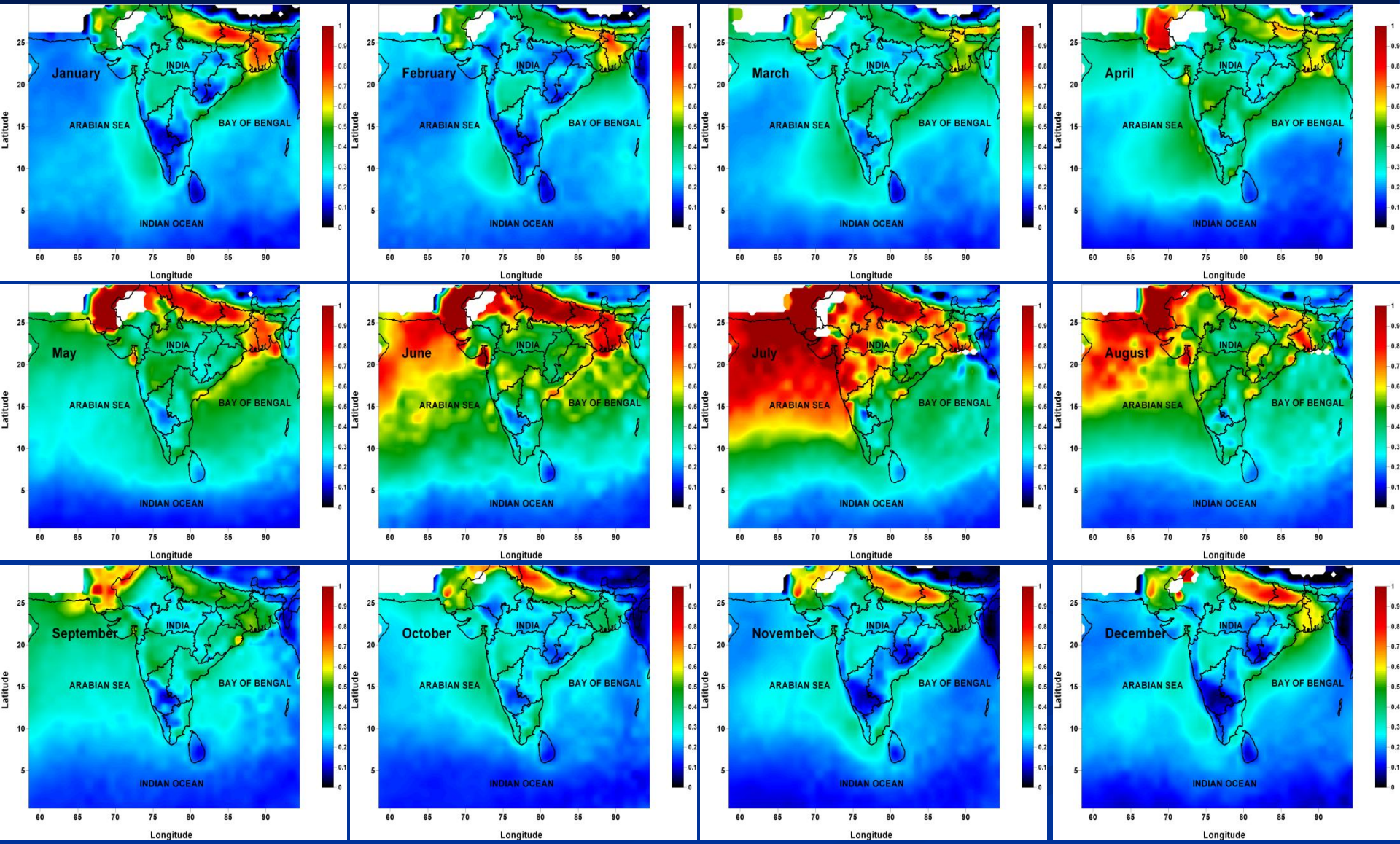
Monthly variation of AOD in south Asia



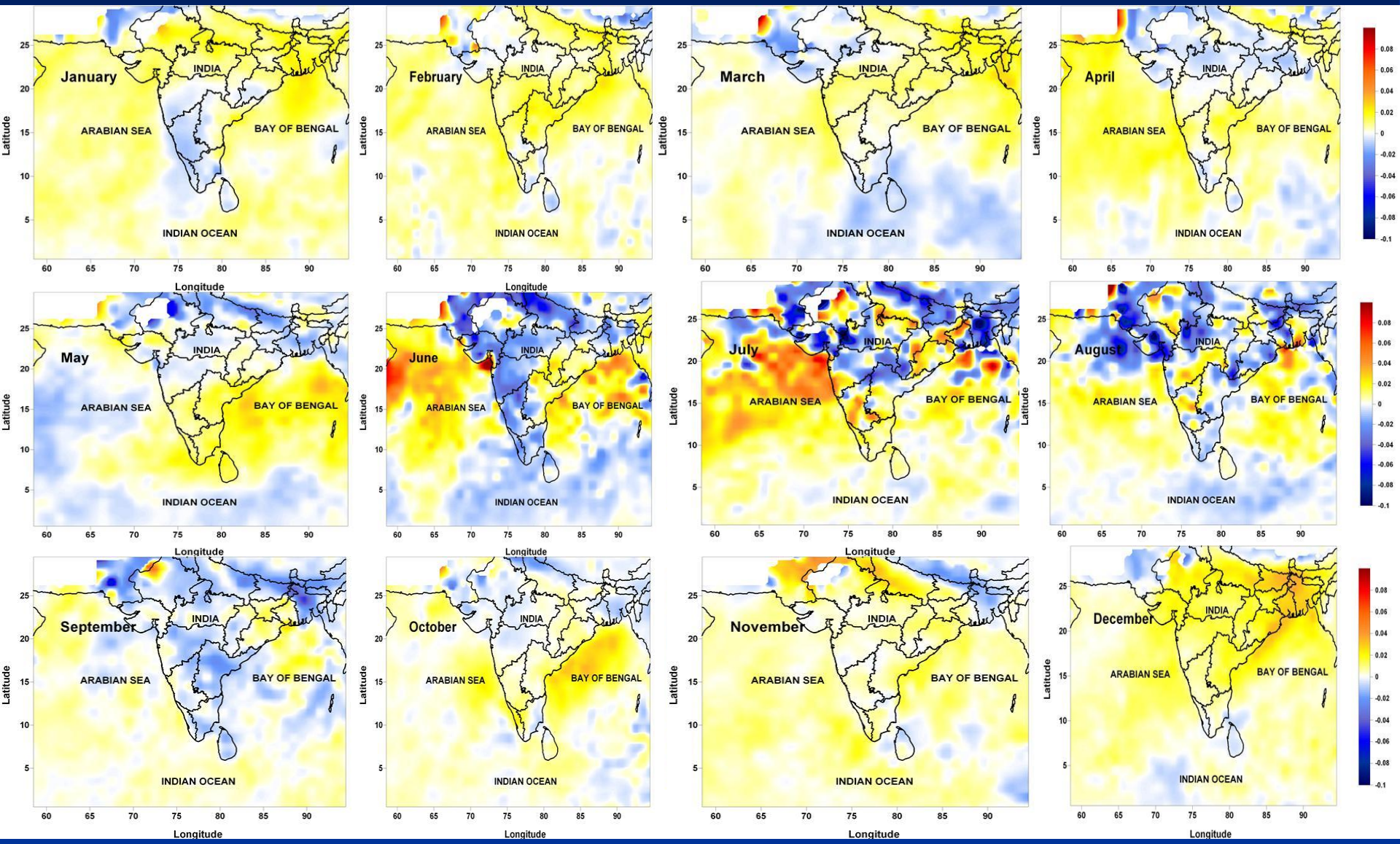


- Terra-MODIS data (2000-2009) over south Asia (0-30°N – 58-95°E).
- Larger AOD_{550} in summer (0.4-0.5), lower in winter (0.25). Larger stdev in summer.
- Similar annual variation in the 4 regions.
- Larger AOD over IGP especially in winter.
- Very large AOD over AS in monsoon.
- Larger AOD over BoB than that over AS in winter and pre-monsoon (ICARB-06 and W-ICARB).
- Lower AOD and annual variation in NIO.

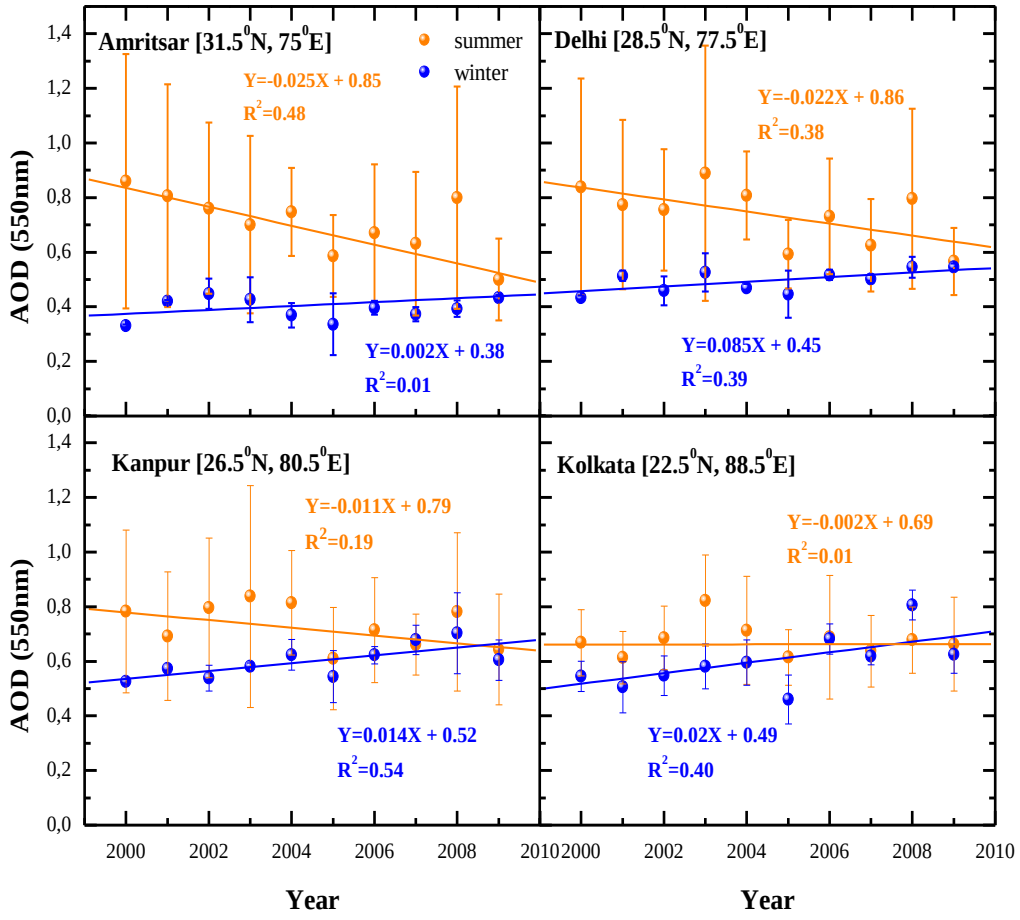
Monthly mean spatial distribution of AOD



Spatial distribution of the AOD trend (2000-2009)

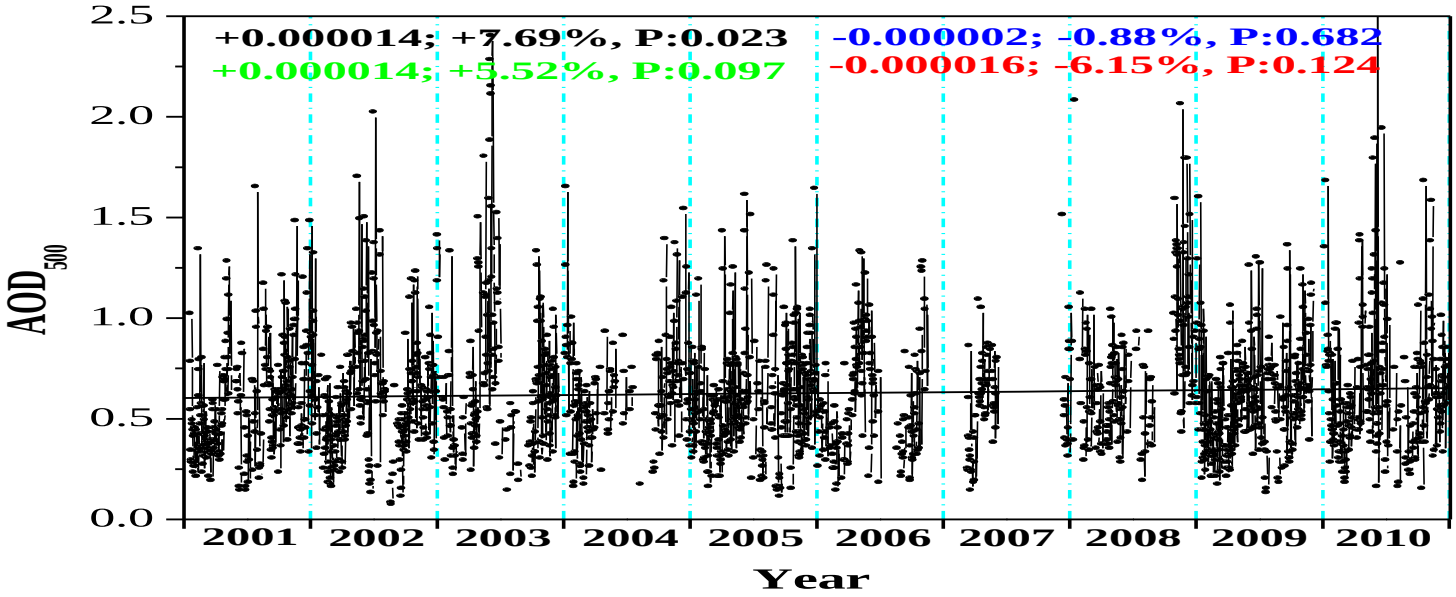


Latitudinal variation of the AOD trend over IGP



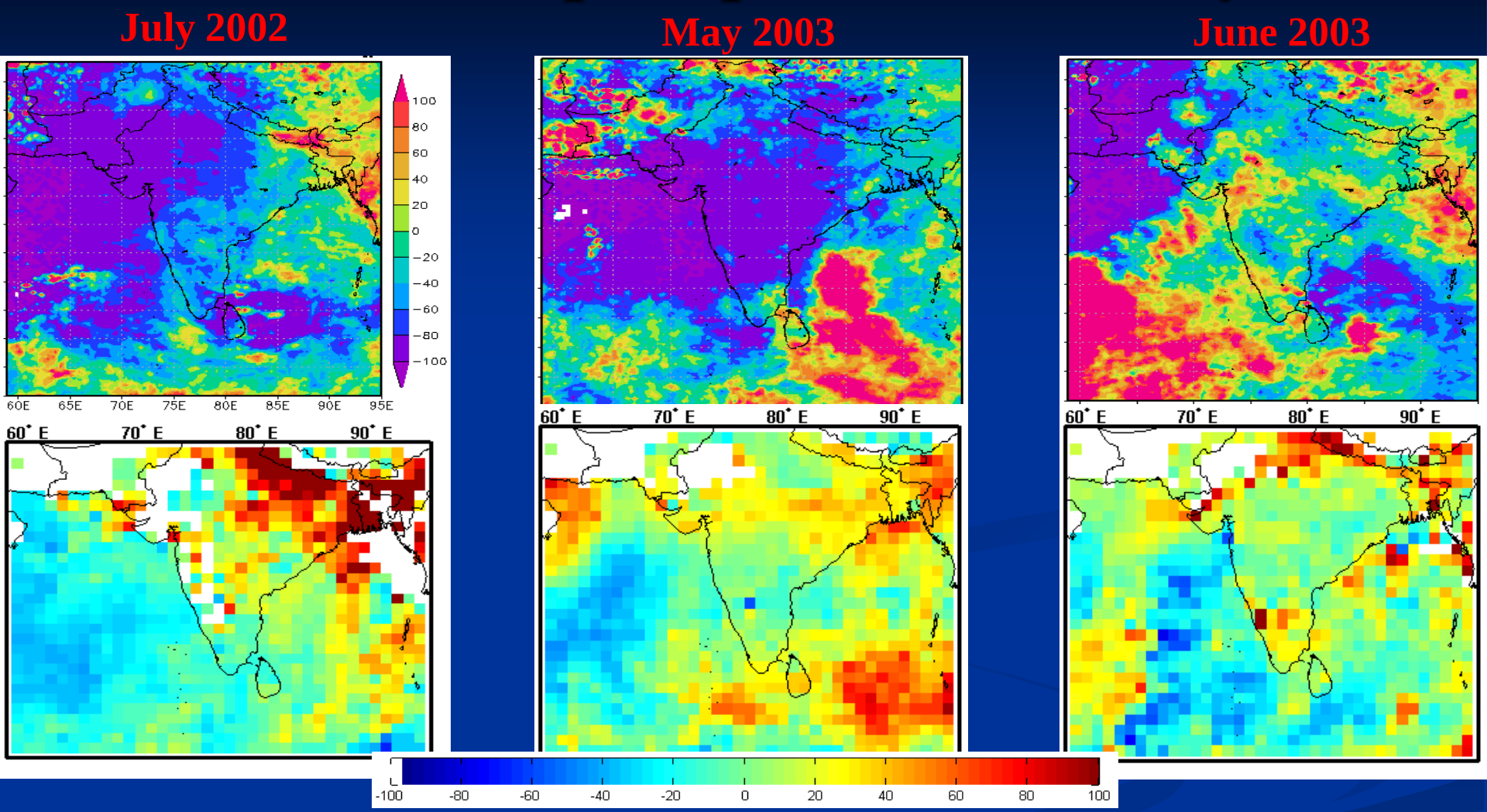
- The figure shows the latitudinal variation of the AOD trend during 2000-2009 from Amritsar (west IGP) to Delhi, Kanpur and Kolkata (east IGP).
- The increasing trend in winter (Dec-Feb) is higher towards east, while the decreasing trend in summer (April-June) is higher in west.

AOD variation at Kanpur AERONET site



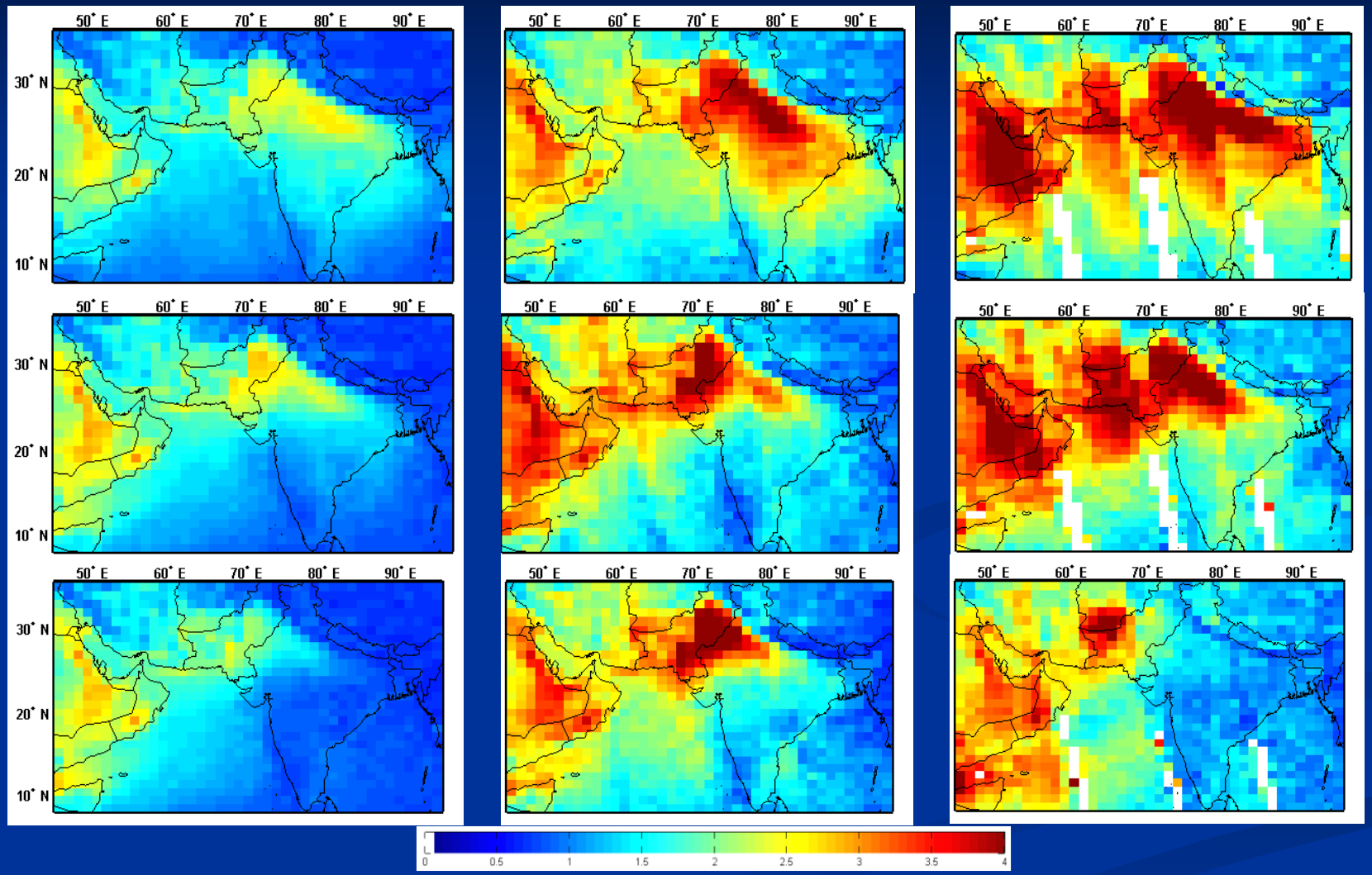
- High AOD peaks in 2002 and 2003 (summer)
- AOD trend for May [-26.9%],June [-8.08%],July [-27.6%]
- **WHY??**

AOD and precipitation anomaly



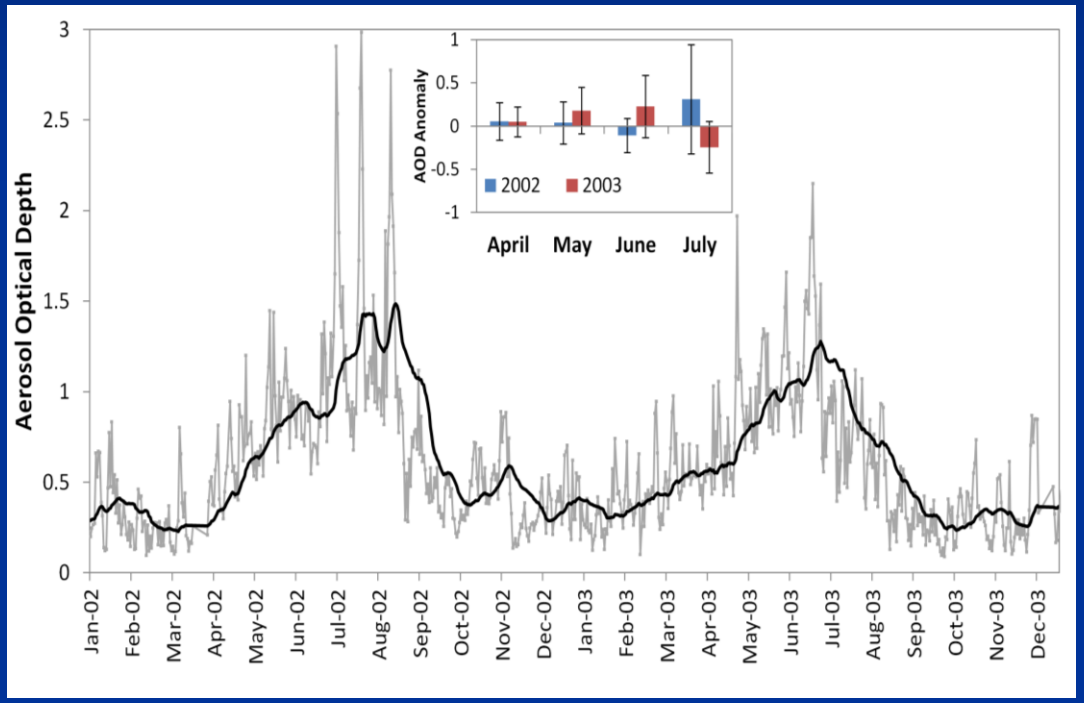
- Monthly normalized rainfall anomaly (%) for July 2002 and May, June 2003 based on the monthly rainfall climatology of TRMM 3B43 V6 during the period 1998-2009.
- Percentage (%) deviation of the Terra-MODIS AOD_{550} for the months July 2002 and May-June 2003 from the monthly mean climatological value during the period 2000-2009.

TOMS-AI anomaly



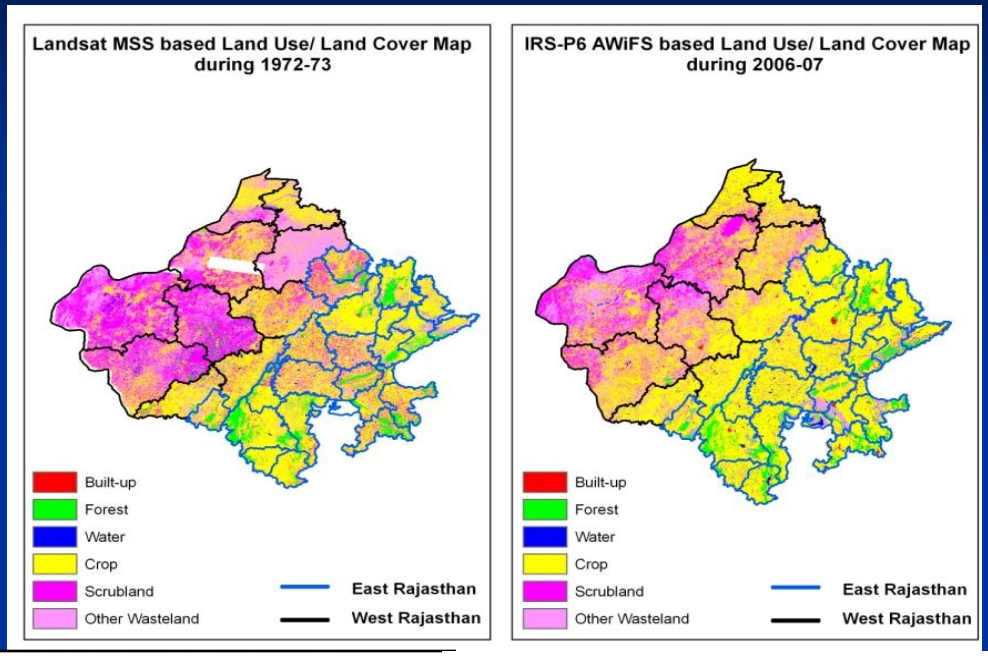
Spatial distribution of the TOMS-AI over South Asia for May (first row), June (second row) and July (third row) during the period 1979-2005 and for the years 2002 and 2003.

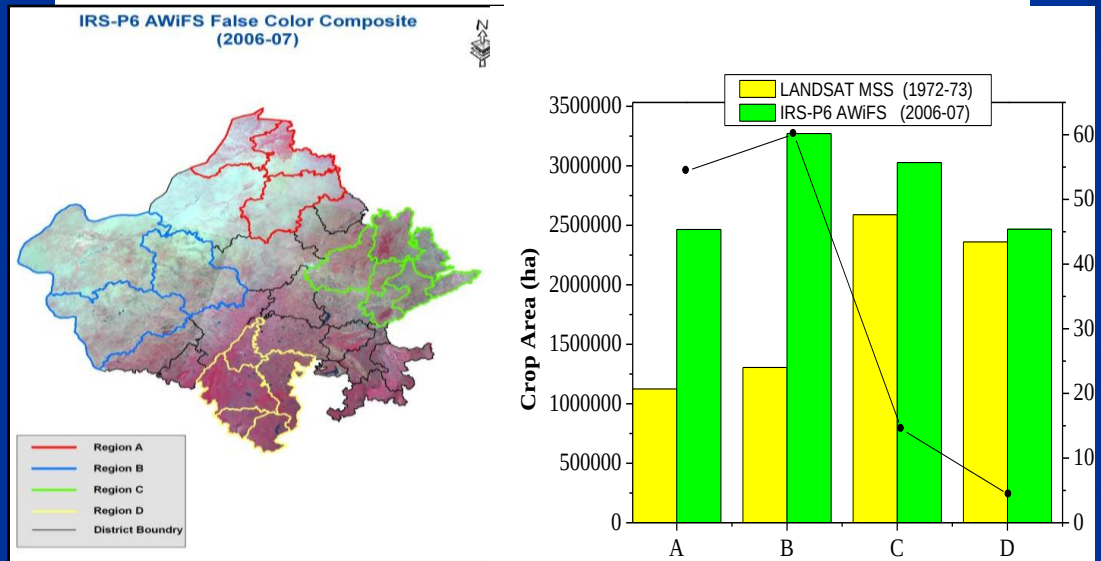
MODIS Deep Blue AOD over Thar desert



- Daily variation of the Terra MODIS Deep Blue AOD_{550} from January 2002 to December 2003 (grey line) averaged over northwestern India (25° – 30°N, 69° – 78°E). The black line is the 30-day moving average over the period. The inset plot corresponds to the monthly mean Deep Blue AOD anomaly for April, May, June and July during 2002 and 2003 from the monthly climatological mean during the period 2000 - 2007 with error bars representing 1 standard deviation from the area-averaged mean.

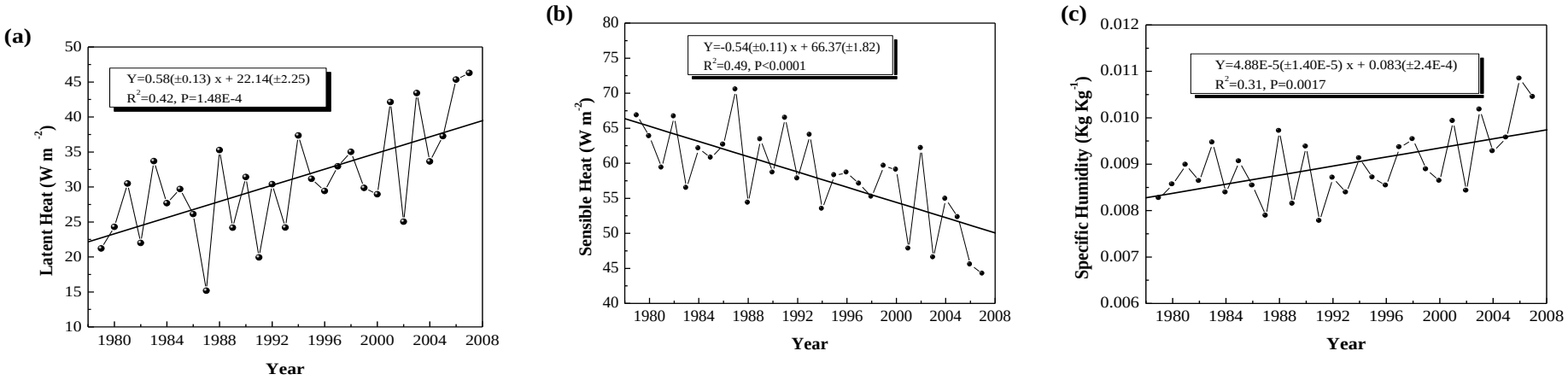
Land Use – Land Cover changes over arid Rajasthan, northwest India





- Land use / land cover map of Rajasthan by means of Landsat-MSS during 1972-73 (left panel) and IRS-P6 AWiFS during 2006-07 (right panel).
- Significant increase in crop-land areas (yellow) and decrease in scrubland areas (magenta) due to irrigation from Indira Gandhi canal.
- Location map of the different regions over east and west Rajasthan considered for estimates on variations in crop areas (a). Absolute (in ha) and percent variations in total crop area between 1972-73 and 2006-07 over the different regions.

Multi-decadal variations in land-atmosphere fluxes over Rajasthan



- Multiyear (1979-2007) variation and trend of the latent heat (a), sensible heat (b) and specific humidity (c) over Rajasthan (24-29°N, 69-77°E) as obtained from MERRA-2D MATMNXLND.5.2.0 dataset.
- The increase in latent heat, specific humidity and the decrease in sensible heat indicate increase in vegetation areas over the arid Rajasthan state.
- The Giovanni MERRA-2D re-analysis results are in satisfactory agreement with satellite observations.

How to improve GIOVANNI?

- Since GIOVANNI is mainly used by scientists without deep knowledge on the algorithm retrievals from the satellite sensors, model simulations, etc it is proposed to include a link for each parameter, mainly for MERRA, NLAS and GLDAS datasets that are unknown to a wider audience, describing each parameter, how it is obtained, which is its physical meaning and how can be used.
- For the current presentation I have to Acknowledge some colleagues that participated in the publications:

  R. Gautam, R.P. Singh, S.K. Kharol, P.R. Sinha.

Thank you